SYNOPSIS

Modern power systems operate close to their security limits and require high speed clearing to preserve transient stability, reduce fault damage, minimize outage duration, and improve power quality. Differential relaying systems provide high speed simultaneous fault clearing for 100 percent of the protected transmission line from all line terminals. Current differential relays only require line currents to determine whether the fault is within the protected zone. They are suitable for the protection of complex transmission network configuration because they exhibit good performance during evolving inter circuit and cross-country faults. In addition, current differential relays are immune to power swings, mutual coupling, and series impendence unbalances. They offer a good application solution for the protection of cables as well as for series compensated, three terminal, and short transmission lines. Line charging current and CT saturation represents major problem to the traditional current differential relays. In which a considerable current difference would appears during over voltages and severe external faults respectively. These problems can be solved by reducing the differential scheme sensitivity or include some intelligence in the protection algorithm. Impact of CT saturation in particular can be also reduced by reconstructing the CT primary current.

After reviewing most of the widely used methods for phasor estimation of power system signals, it is observed that there is a strong motivation to develop a robust approach for the detection, classification, and location of faults on a transmission line either fed from both the ends or is a part of a wide area power system network. In this research, a new fast discrete S-transform algorithm, with a new frequency scaling and band pass filtering paradigm is presented for evaluating the spectral energy for either differential or impedance protection of transmission

lines. A rough calculation of computational timings shows that the new fast discrete S-transform (FDST) is almost 30 times faster than the conventional ST and thus has the potentiality of being implemented in real-time. Instead of formulating the FDST by the fast Fourier transform (FFT) approach for each individual frequency scaling, an elegant generalized matrix formulation is studied to obtain fast discrete S-transform of signal samples and then the elements of this FDST matrix will be modified according to a particular scaling and band pass filtering approach. The new formulation will be used for computing fundamental phasors for fault location calculations in transmission lines.

To prove its effectiveness in fault location calculations a meshed power system with several generators and transmission lines is taken for study. Such a system will be useful for wide area systems in smart grid applications. Also for comparison, the robust Gauss-Newton algorithm will be used for impedance computations and hence the fault location. This formulation will also examine the problems of decaying dc and CT saturation aspects in distance protection. The dc rejection is a difficult problem and a number of research papers have been published in this area and complicated techniques have been proposed without much success in the cases where noise level is high.

The main objectives of the thesis and major contributions are summarized as:

1. To make the conventional time-frequency analysis technique like the discrete S-transform much faster to estimate fundamental phasors of voltage or current signals during the occurrence of faults on power system networks.

2. To further apply this novel fast discrete S-transform (FDST) and a cumulative sum average (CUSUM) technique for the detection, classification, and location of faults in a new differential protection scheme for power transmission lines fed from both the ends.

3. There is a strong motivation to apply the current differential protection scheme to a shunt compensated meshed power network which is a part of a large power system using the FDST algorithm. The impact of the shunt compensating device namely the STATCOM on one of the lines of the meshed power network will be evaluated for fault detection and classification in a differential protection scheme.

4. The fourth important objective of the present research is to apply this novel S-transform variant to locate faults in a wide area interconnected power system. The power system will comprise a meshed system with several sources. Also the performance of the novel S-transform will be compared with a recently published robust Gauss-Newton algorithm to prove its superiority over the later.